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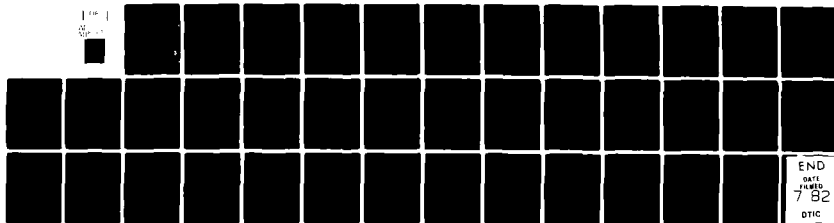
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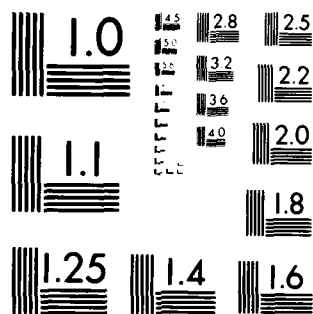
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ABSTRACT

A new testing facility for research on canine olfaction was established. Instrumentation incorporates recent improvements in odor stimulus production and control techniques and provides a means -- through automated program control -- to obtain simultaneous measurements from up to four independent testing chambers. Enhancement of odor detection performance following systemic administration of the same odorant ("sensitization") generally occurs from 5 to 12 days after ingestion of a small measured quantity of the odorant. The maximum performance level subsequently achieved is seen as an elevation of scores roughly equivalent to that typical for a ten-fold higher test concentration. This performance elevation either declines back to baseline, within about one week, or is sustained for many weeks. The sensitization effect does not occur if the ingested odorant differs markedly in structure from the behavioral testing odorant, a finding that indicates relative specificity of the effect and suggests that its site of origin is at the receptor level. A comparison was made of the performance of German shepherds and Fox terriers during the initial acquisition phase of training on a forced-choice odor detection task. Handlers directly controlled the dogs by the use of a hand-held lead and voice commands. The two breeds display clear and generally consistent differences in their responses to handlers. Only marginal success in establishing effective and sustained dog-handler working relationships was obtained with terriers. In general, the terriers proved to be more distractable, less focussed on the detection task, and more difficult to control than the shepherds. Observations suggest that, in the case of terriers, success in training on a handler-controlled task may require greater emphasis on establishing criteria for selecting individuals than we have found necessary in working with shepherds.

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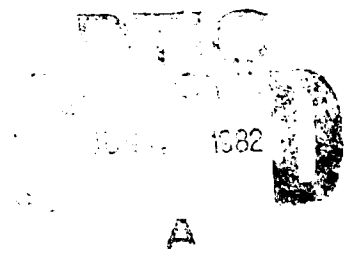
ENHANCEMENT OF OLFACTORY DISCRIMINATION

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SUMMARY

We have established a new testing facility for research on canine olfaction. Instrumentation incorporates recent improvements in odor stimulus production and control techniques and provides a means -- through automated program control -- to obtain simultaneous measurements from up to four independent testing chambers.

Enhancement of odor detection performance following systemic administration of the same odorant (which we have termed "sensitization") generally occurs from 5 to 12 days after ingestion of a small measured quantity of the odorant. The maximum performance level subsequently achieved is seen as an elevation of scores roughly equivalent to that typical for a ten-fold higher test concentration. This performance elevation either declines back to baseline, within about one week, or is sustained for many weeks. The sensitization effect does not occur if the ingested odorant differs markedly in structure from the behavioral testing odorant, a finding that indicates relative specificity of the effect and suggests that its site of origin is at the receptor level.

We compare the performance of German shepherds and Fox terriers during the initial acquisition phase of training on a forced-choice odor detection task. Handlers directly controlled the dogs by the use of a hand-held lead and voice commands. The two breeds display clear and generally consistent differences in their responses to handlers, each of whom -- following a standardized set of training procedures -- related to all dogs, as nearly as was possible, in a

uniform manner. With the terriers, we had only marginal success in establishing effective and sustained dog-handler working relationships. In general, the terriers proved to be more distractable, less focussed on the detection task, and more difficult to control than the shepherds. Specifically, although the better performers of both breeds appear to be equally sensitive to odors, attempts to shape and maintain consistent session-to-session performances were moderately successful, at best, for three out of four terriers. Only one out of four shepherds failed to achieve satisfactory performance under the same training conditions. Our observations suggest that in the case of terriers (and probably other small breeds, as well), success in training on a handler-controlled task may require greater emphasis on establishing criteria for selecting individuals than we have found necessary in working with shepherds.

NEW LABORATORY FOR RESEARCH ON CANINE OLFACTION

Much of the effort expended during the final reporting period focussed on the design, installation, construction and testing of components of a new computerised facility for research on canine olfaction. We know of no other laboratory of this kind. Now nearing completion, it will allow expansion of our existing research potential severalfold and represents a tripling of available laboratory space (with the new space renovated at no cost to this grant). Many of its component parts are newly designed or are extensively redesigned on the basis of our experience with existing apparatus. We are continuing studies to establish the design of yet other components which has necessitated extensive consultation with machinists, a glass blower, specialists in electronic design and in operation and programming, as well as a chemical engineer specialising in gas dynamics. The overall purpose of the design has been to allow, simultaneously, flexibility and automatic operation of several testing chambers in a situation that eliminates potential nonolfactory cues, (particularly sound), minimizes odor contamination and facilitates cleaning of the apparatus. Since the system is not yet completed we shall not describe it fully here but outline some representative details.

The most prominent feature of the facility is a controlled environment room whose external dimensions are 12' 6½" long, 5' 10" wide and 8' 4½" high (Figure 1.) It maintains an internal temperature of $22^{\circ} \pm \frac{1}{2}^{\circ}$ (by means of a water-cooled 1 HP compres-

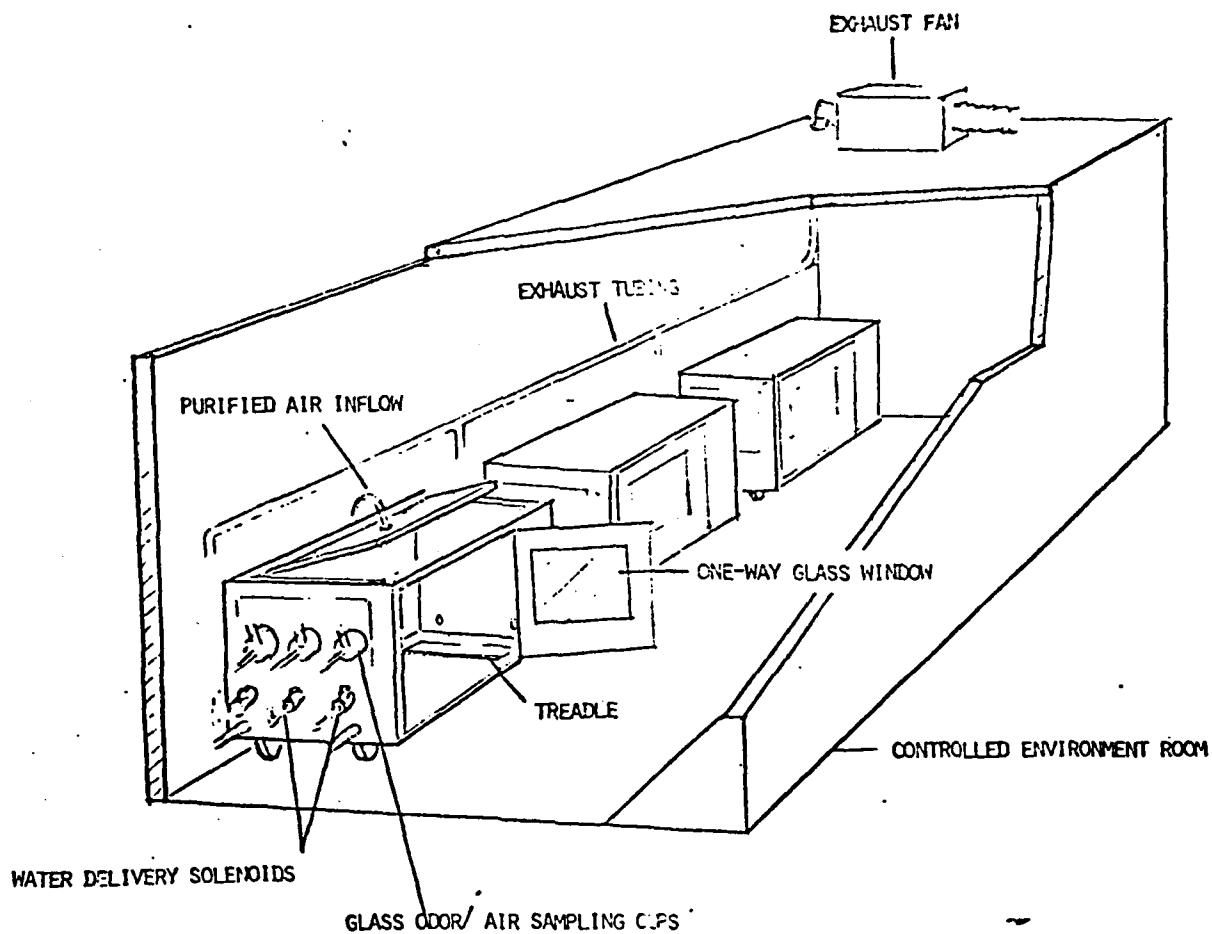


FIGURE 1, SIMPLIFIED VIEW OF THE CONTROLLED ENVIRONMENT ROOM CUT AWAY TO REVEAL THREE BEHAVIORAL TEST CHAMBERS. THE CHAMBER IS SHOWN WITH ROOF AND SIDE DOOR OPEN. IN THE INTERESTS OF CLARITY, THE ROOM AND CHAMBER ARE SHOWN STRIPPED OF ALL BUT A FEW FEATURES. FOR EXAMPLE, THE EXHAUST SYSTEM, OLFACTOMETER, AIR CONDITIONER, AIR PURIFICATION STAGES, INLET/OUTLET MANIFOLDS, PHOTOSENSORS, WATER RESEVOIR AND VARIOUS CONTROL SYSTEMS ARE EXCLUDED OR ONLY PARTIALLY DEPICTED.

sor and heaters) but this can be raised to 60° in order to deodorise the test boxes and test environment between trials on different odorants and different concentrations of the same odorant. Although the room has the capacity to house 6-8 behavioral test boxes, we currently have sufficient funds to complete three. The room also contains an olfactometer for delivering odor and air to the test boxes at a known concentration and flow rate, as well as components of the odor/air exhaust system. Other systems are housed outside the environment room in the main laboratory. These include the air purification unit and associated manifolds, exhaust motors with ducting to the exterior of the building, white noise generator, and the experimenters station. It will ultimately include the computer, video terminal, printer, and interface system. (Funds for a PDP/11 microprocessor and associated terminals became available in the 1979-80 budget period). The computer will allow for more extensive recording and analysis of the data than is presently possible. It also has the capacity to program the operation and data acquisition for up to ten test boxes.

An example of the fundamental design changes that are being made, is the odor-air presentation unit. In the existing apparatus this takes the form of a 'wind tunnel' or 'bay' through which flows air or odor delivered from the olfactometer. In the new apparatus, the bay is replaced with a double glass container or 'cup': an inner cup nested inside an outer (Fig. 2). The outer cup is connected to a vacuum source so that it draws the

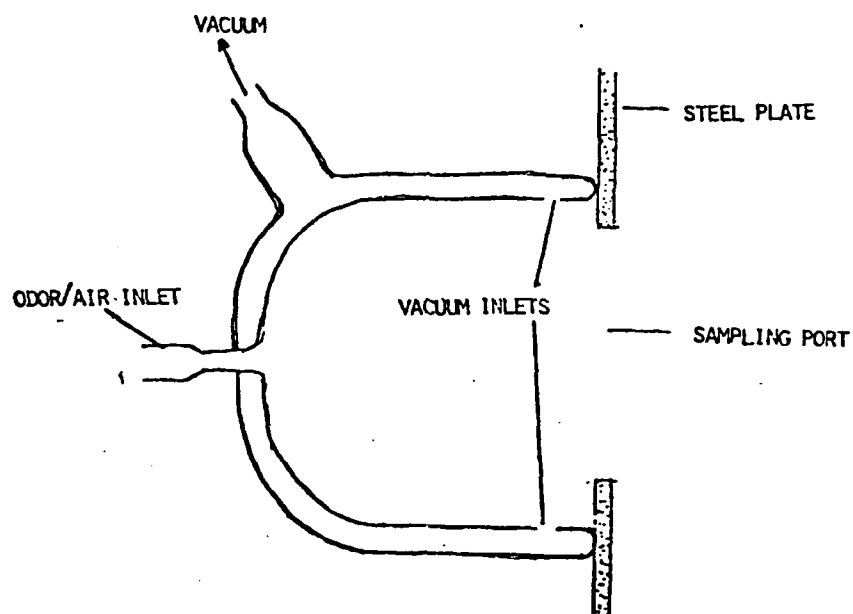


FIGURE 2. SECTION THROUGH ODOR/AIR SAMPLING CUP. EACH GLASS CUP IS ATTACHED TO THE STEEL PLATE BY SPRINGS (NOT SHOWN). THE VACUUM EXHAUSTS ODORS THAT ENTER THE INNER CUP, THROUGH A RING OF VENTS THAT CONNECT TO THE OUTER CUP. THE DOG INSERTS ITS SNOUT THROUGH THE SAMPLING PORT WHICH IS A CIRCULAR HOLE CUT IN THE STEEL PLATE. A STEEL GATE SLIDES DOWN TO CLOSE THE PORT BETWEEN TRIALS.

odor or air out of the inner cup through a series of holes near the margin of the inner cup. Test stimuli, odorized or blank air, are delivered to the base of the inner cup, and a dog samples this vapor by sniffing into the cone. The circle of exhaust ports thus prevents the dog from drawing in room air while sniffing. The dimensions of the inner cup are such that the dog's snout fits comfortably into it without touching the sides. When the dog inserts its snout fits comfortably into it without touching the sides. When the dog inserts its snout into the cup it interrupts an infra-red photecell bean directed horizontally at a photosensor. This signals the interruption to the computer which tallies the number and duration of each insertion. If the interruption does not exceed five seconds there is no consequence. However, a sustained interruption of five seconds is signalled as a choice. If the dog is correct it withdraws its snout from the cup and obtains a water reward from a spout inside the main testing box. If it is incorrect, a steel door descends to isolate the cup from the main chamber of the testing box. The cup is attached to the steel plate, through which the dog inserts its nose, by springs. Thus the entire cup is easily removed for cleaning. It has the additional advantage of allowing the movements of the dog's snout to be observed. A final design feature is the form of the odor/air delivery tube

that terminates at the base of the cup. This incorporates a small chamber which creates turbulence and ensures the even distribution of the odorous vapor over the dog's snout.

ENHANCEMENT OF ODOR DETECTION PERFORMANCE IN DOGS FOLLOWING ODORANT INGESTION

Introduction

The major aims and progress on this study have been outlined in previous reports and will only be summarised briefly here. Briefly, we found that a remarkable enhancement could be induced in the performance of german shepherds on an odor detection task if they receive a liquid dose of 1-6 ml of the same odorant and generally returned to baseline within a few days. The peak performances were unusual in that they exceeded the performances ever previously achieved by the dogs on that concentration.

We also found that the enhancement effect only occurred if the test odorants and the ingested odorant were one and the same or at least closely similar in structure. Thus when a female dog ingested one ml of α - ionone and was required to detect pentyl acetate in the vapor phase no enhancement in performance appeared. α - ionone (a ketone) is structurally quite dissimilar to pentyl acetate.

This enhancement has a number of puzzling features. While it has a time course comparable to that of an immune response it does not show certain of the classical properties of an immune response. For example, there is little to suggest that performance is enhanced more markedly following a second exposure to ingestion of the test odorant, although this possibility cannot be ruled out as yet. Because it has considerable potential significance both as a technique for enhancing the performance of dogs on

specific odor detection tasks under field conditions, and a tool for elucidating the mechanisms underlying odor detection and recognition, further studies have been undertaken. These are directed at determining whether dose level of the ingested odorant controls the amplitude of the effect or the extent to which it is sustained, and establishing more firmly the specificity of the effect. It has also been necessary to repeat certain studies on new animals in order to establish the reliability of our observations. Because it often takes many weeks to bring an animal down to a concentration that elicits a performance approaching chance (which is the optimal working level) and further time to stabilize performance at that level to establish a baseline, these experiments are extremely time consuming and in a sense, delicately balanced (since dog's performance can easily be disrupted so that the reference has to be reestablished).

Method

Three german shepherds were the subjects. They were trained and tested in the apparatus shown in Figure 3. The test chamber consists essentially of a main chamber with a treadle, opening through three doors to three wind tunnels at the front of the chamber. Odor or air reached each tunnel at its base and was exhausted from above; the odor/air sequence was controlled by solenoid valves, so that two tunnels always received air while the third received odorant delivered from an olfactometer. The dog indicated a response by holding its snout inside

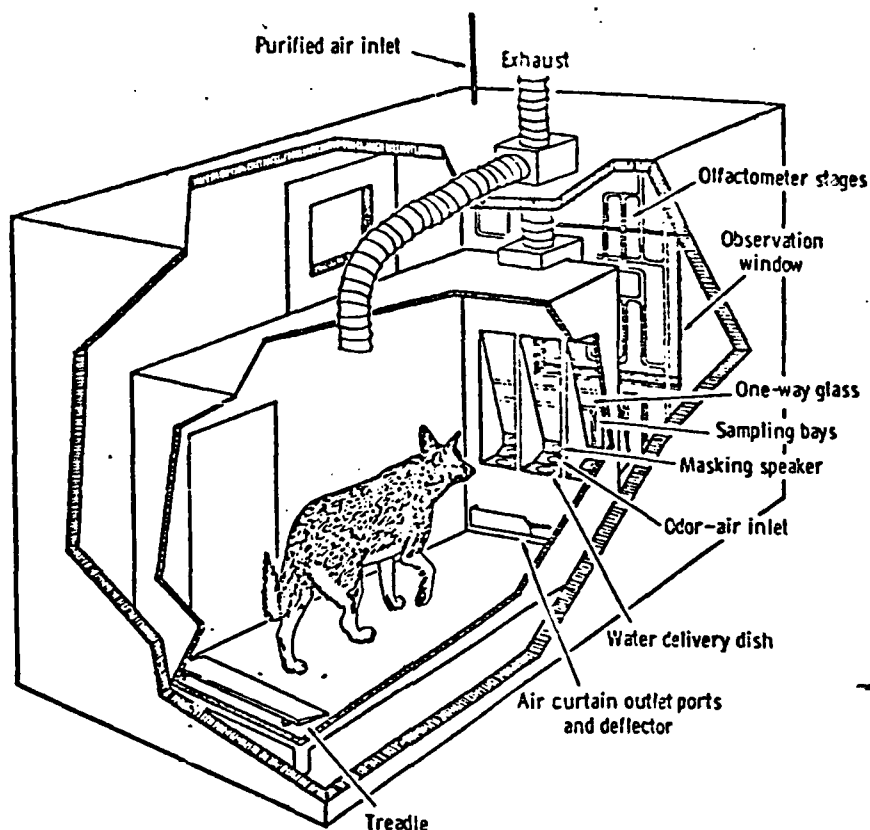


Fig. 3. Simplified view of controlled environment room containing test chamber. The height of the room has been reduced and certain details omitted for the purposes of illustration. (A gas chromatograph and water reservoir bottles normally rest on the roof of the chamber and an air conditioning unit and purification stages are housed on the roof of the room. The vapor saturator is not visible and the olfactometer is shown in simplified semischematic form.) The one-way glass windows normally reflect rather than transmit light from the angle shown here. (from Moulton & Marshall, 1976)

the appropriate tunnel and thus interrupting the beam directed horizontally across the entrance to the bay at a photocell.

Procedure

Preliminary Training: The olfactory detection performance of a dog was first assessed at a value of vapor saturation of pentyl acetate that resulted in a percentage correct score between 40% and 60% where chance is 33%. This happened to be 10^{-6} in one case and $10^{-6.25}$ of vapor saturation in the other cases. The animal initiated a trial by depressing a treadle. This initiated the opening of the glass doors giving access to the tunnels. One stream was associated with pentyl acetate and the others with filtered air ('blanks'). If the dog made the correct choice and selected the odorant it received a water reward. If incorrect, all doors closed. The intertrial interval was 30 secs and allowed for the interchange of odor and air flows to the tunnels.

After a baseline performance was established over a period of many sessions, the oral ingestion experiment began. During both preliminary training and definitive trials one or two sessions were conducted daily six days a week for each animal.

Odorant administration. Odorants were administered in gelatin capsules. Placebos consisted of a capsule containing mineral oil.

Experimental procedure. Dog 5M (female) was tested first on a placebo then on 3ml of pentyl acetate and finally on 6ml pentyl acetate. The performance of the dog was judged to be poor and a period of retraining was instigated to restore

the baseline to an optimum level. The animal then ingested 3ml pentyl acetate and was tested for about two months. To determine if the performance at an enhanced level required continuous testing to maintain its amplitude, trials were interrupted for a week, before continuing them again. Dog 4B (male) showed no enhancement of performance following ingestion of a placebo or 1 ml of pentyl acetate. However, it was conceivable that the dose level was too low. Consequently, the dog received 3ml of pentyl acetate after a further period of baseline training. After more than 5 weeks of testing, the performance of the animal was allowed to decrease to chance by delivering blank air through the odor lines of the olfactometer. Another baseline training period for detecting pentyl acetate was then instigated followed by a final dose of 3ml pentyl acetate. A younger dog, not previously exposed to odorant ingestion, was used to provide further evidence concerning the specificity of the effect. After a baseline performance had been established on 10^{-6} pentyl acetate, this dog (6 Sa, male), ingested first 3 ml α - ionone, then -after an appropriate period - 3 ml d-limonene, and finally after sustaining baseline for several weeks, 3 ml of pentyl acetate.

Results

Dog 5M failed to show enhancement of performance following ingestion of a placebo, 3ml or 6 ml of pentyl acetate. However, the dog did not appear to be performing optimally during this and following a period of retraining a more effective baseline

performance was established. The dog was then retested on 3 ml amyl acetate. As is shown in Figure 4, its performance now began to rise five days after ingestion of the odorant and plateaued within the range of 80 - 95% correct where chance is 33%. After about 45 days at this level the experiment was interrupted for a week. Upon resumption of the testing the performance was found to have dropped but rapidly regained the former level. The performance of dog 6Sa demonstrates clearly that ingestion of compounds with structure dissimilar to that of the odorant being detected does not result in enhancement of performance. Ingestion of the same odorant, however, does. As has been observed in several previous cases, it also results in an initial depression in performance. Thus the overall effect is a marked increase in variance. Certain of these features are apparent from Table 1.

ODORANT INGESTED	MEAN BASELINE PERFORMANCE (PREINGESTION)	NO. OF SESSIONS	MEAN POSTINGESTION PERFORMANCE	NO OF SESSIONS
α IONONE	78.9 \pm 4.1%	7	66.1 \pm 8.5%	14
d-LIMONENE	50.2 \pm 5.7%	6	51.1 \pm 5.2%	14
PENTYL ACETATE	53.5 \pm 8.3%	20	(45.6 \pm 16.8%)	8

Table 1. Performance of dog 6Sa before and after ingestion of three different odorants. The dog was being tested on 10^{-6} of saturated pentyl acetate vapor throughout. The mean baseline performance are expressed as percent correct \pm Standard Deviation.

None of the mean session scores following ingestion of either α -ionone or d-limonene exceeded the highest scores recorded in

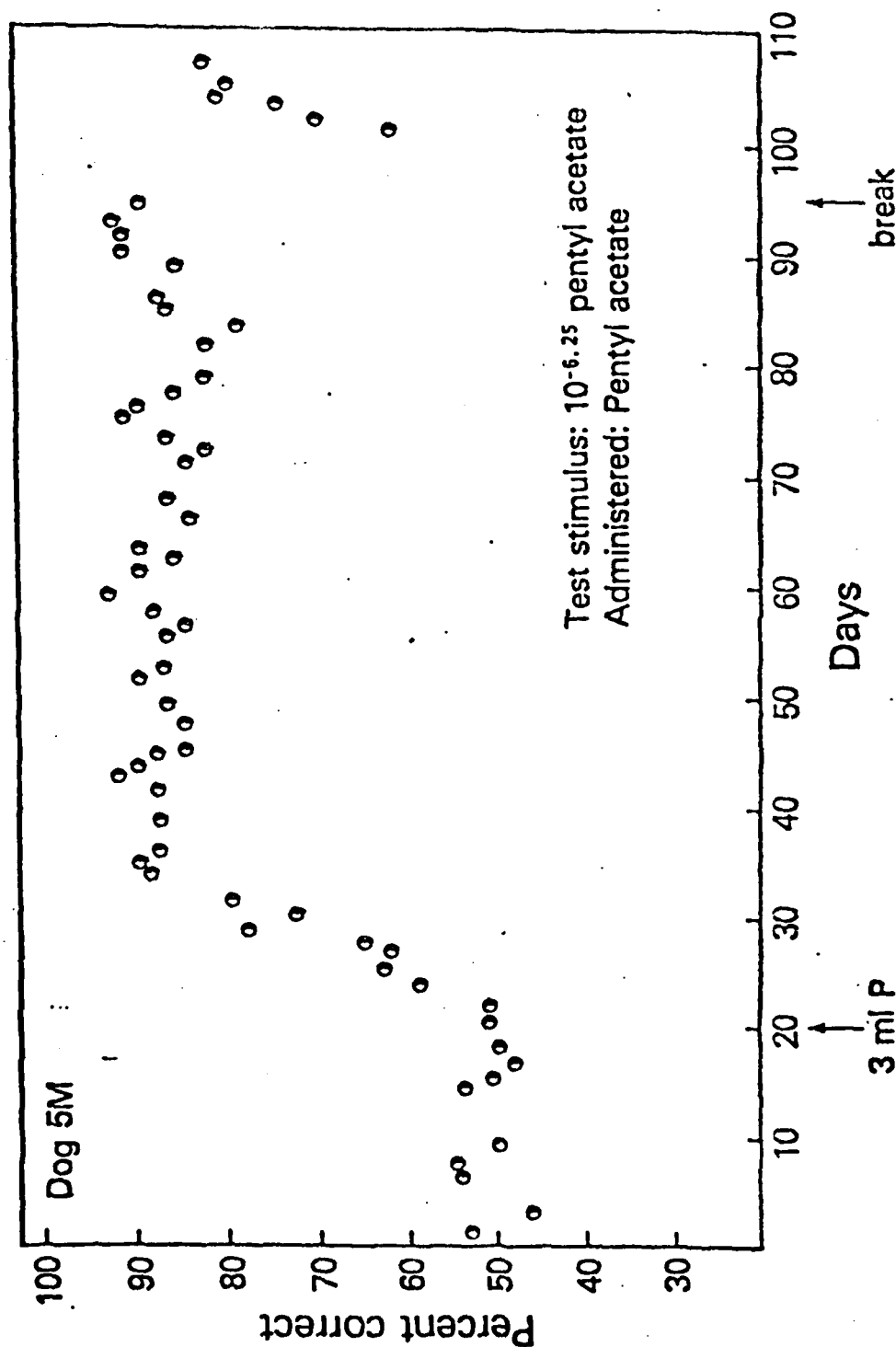
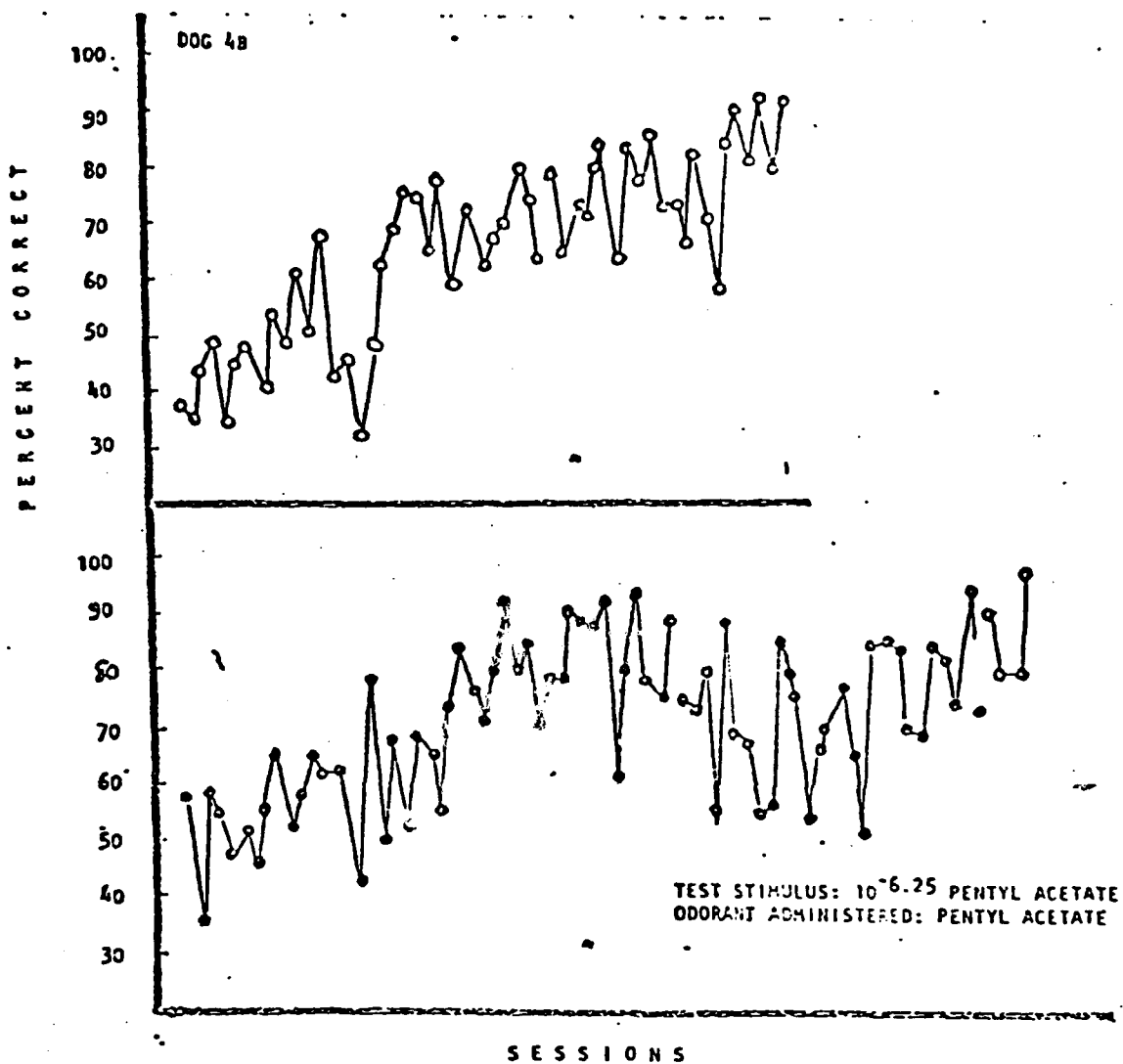


Fig. 4, Dog 5M was trained to detect pentyl acetate diluted to $10^{-6.25}$ of vapor saturation. Its performance on this odor had stabilized within a range of 45-55% correct (chance score-33%) over for more than 20 days when 3 ml of pentyl acetate in liquid form was administered orally (in a capsule). After about five days performance began to improve to reach a plateau within range of 80-95%. It maintained this level for 45 days at which point the experiment was interrupted for one week to determine if a pause would modify the performance. Upon resumption of testing the performance rapidly ascended to its previous plateau.



Figures 5a & 5b. Performance of Dog 4B during baseline pretraining (first 5 sessions in (a) & in (b).) and following ingestion of 3 ml of pentyl acetate. ($10^{-6.25}$ of saturated vapor). The acetate was administered between the 5th and 6th sessions in each test period. (1a)=Test Period I and (b)=Test Period II).

the pre-ingestion period. From this fact alone it is clear (without statistical analysis) that no enhancement occurred.

The data for pentyl acetate have been included in Table 1 for comparison but the post ingestion performance is quite distinct from that seen with either α -ionone or d-limonene. Thus the range of mean session scores in the 20 sessions preceding ingestion of pentyl acetate was 40-68 percent correct. In the post ingestion period, however, they ranged from 26-75. These scores reflect the marked oscillations in performance that we have previously noted following ingestion of the odorant being detected, and particularly, the depression that frequently falls in the first or second pre-ingestion day as well as the marked enhancement (to a level not attained on any of the 20 pre-ingestion sessions) occurring on the 7th post-ingestion day. Unfortunately, the dog developed a respiratory infection on the 9th day of testing and the experiment had to be discontinued before it could be determined (a) whether the peak had been reached or (b) if the peak was sustained or not. However, the dog has not recovered and is currently being retested to determine whether its performance is at or near the baseline (preingestion) or has remained at the peak level.

Discussion

These results confirm that the phenomenon of enhancement is a real one and, in conjunction with the earlier data, establish that the main increase occurs no sooner than seven days after odorant ingestion. In the few instances when the phenomenon

did not materialise following ingestion it has been with an animal that was performing poorly.

Evidence for the specificity of the effect previously rested on only one experiment. We now have shown that not only placebos, but also two odorants structurally dissimilar from the vapor phase odorant, fail to induce enhancement. A similar conclusion applies to the marked depression in performance that normally occurs on the first or second postingestion day (i.e. it is only seen when the odorant ingested is the odorant being detected).

The major new factor injected by the present data is the evidence that the effect can be sustained in some cases and transient in others. The reasons for the difference are not clear, although either a higher dose level of the ingested odorant or an experimental history of previous ingestion of the odorant, are the two most likely candidates. Whatever the case, the practical consequences are striking: under certain conditions it may be possible to improve a dog's performance to a level never previously attained by oral administration of the same odorant. This is not a marginal result: it would necessary to raise the concentration of the test odorant by as much as a factor of ten to achieve a comparable effect.

ODOR DETECTION TASK ACQUISITION: A COMPARISON OF GERMAN SHEPHERDS
AND FOX TERRIERS

Introduction

Background. Differences in olfactory acuity among several large breeds of dogs are reported to be small by comparison to those separating dogs from man and other animals. In a large sample of German shepherds and two other breeds, Neuhaus (1957) found thresholds for the detection of butyric acid vapor to vary by less than a factor of ten, and to be $1 - 2 \log_{10}$ units of concentration below values measured for a Fox terrier. Although the absolute values for thresholds reported by Neuhaus are in some instances questionable (cf. Moulton et al., 1960), the relative differences that he found are probably accurate, and it thus could be that in a smaller breeder, such as the terrier, detection thresholds are slightly higher. Additional data clearly are required for a valid comparison, however, and one aim in our continuing studies is to obtain such data.

Current work. The use of a controlled environment chamber housing automated testing apparatus offers important advantages in isolating the subjects from interfering variables and ensuring uniform stimulus and response conditions. On the other hand, performance measurements obtained under these conditions obviously do not answer questions concerning performance effectiveness in odor detection tasks requiring ongoing co-operation between a dog and its handler. This was the case in our earlier studies of nasal airflow during odor sampling -- the dogs being tested on a leash under the direct control of a handler. While we have

had generally good success in training shepherds by this method, we were less successful with terriers, a result that appears to reflect breed differences more in temperament -- as we discuss below -- than in abilities to detect and respond consistently to odors.

In the present account we relate a series of observations focussing specifically on the performance of Fox terriers during the early phases of odor detection training by a handler. We compare the performance of terriers with that of shepherds and comment on subsequent results with the terriers when training was contained using the automated testing apparatus.

Methods

Subjects. Observations are based on four German shepherds (three females, one male; the male and two females were littermates) and four smooth-coated Fox terriers (three males, one female; all but one male were littermates). All were maintained on 23 h water deprivation with measured daily total water quantities given as a combination of rewards delivered during testing and the remainder given at feeding time mixed with food.

Handlers. Three handlers participated in this work. Each received instruction under supervision of the experimenter with special emphasis placed on consistency in relating to all dogs and in the use both of voice commands and verbal rewards. During sessions, upon entering the testing run, voice contacts with dogs were kept to a minimum; the standard four were: "Sit" (prior to a trial), "Ready Go" (the start signal), "No" (for errors),

and "Good Dog" (given immediately as a "bridge stimulus" between a correct response and the arrival of water at the delivery bowl).

Apparatus. The apparatus was a two-choice testing console located at one end of an indoor kennel run measuring 3.5 m long by 1.5 m wide. The console provided a pair of odor/blank sampling ports, mounted side-by-side, beneath each of which was a bowl for delivering water rewards when the handler activated an electrically-controlled valve. This apparatus is essentially the same as we used in our studies of sniffing, and is detailed in earlier reports.

Test stimuli. The odor stimuli were liquid dilutions of *n*-pentyl acetate (expressed as percentages: vol/vol) in ethylene glycol, a standard diluent having little or no odor. Blanks were ethylene glycol alone.

Procedures. Training was begun with a 0.1 percent odor concentration using a minimum of 10 trials/session. The odor and blank stimuli (concealed behind the right and left sampling ports) were interchanged from trial-to-trial according to a modified random (Gellerman) sequence. Standard operant shaping procedures were used to establish the following final sequence of responses: approach to and sniffing at one or both sampling ports, and -- depending upon which one contained the odor stimulus -- lowering snout to touch the reward bowl beneath the correct port. If the dog lowered its snout at a bowl before sampling at either port, or if the choice was incorrect (the blank stimulus), the trial was immediately terminated and the dog was led back to the

start position to await the next trial. During the inter-trial-interval the handler first tethered the dog, interchanged stimulus positions (if dictated by the sequence), used an air blower to flush out both sampling ports, and finally, set the reward switch on a hand-held control to the appropriate water delivery position ("right" or "left") for the next trial. When a dog reached and remained at or above 90 percent correct responses for three consecutive sessions, the odor concentration was lowered by a factor of 10 (one \log_{10} unit) and testing was continued.

Results

Our primary concern in testing on this task was initially with pre-training for later tests using the automated apparatus, and secondarily, with quantitative performance measurements. As a result of relatively unsuccessful attempts to establish stable performance levels, however, it became apparent either that there was a problem with the training procedure (which had not surfaced in working with shepherds), or that the problem was one with the breed, or more likely, with individuals of the particular litter we obtained. For this reason we emphasize behavioral observations and concensual impressions shared among the handlers rather than performance data.

For objective comparisons, however, and to point out major performance features, Fig. 6 shows scores for the two best subjects of each breed over the final 10 sessions at the initial

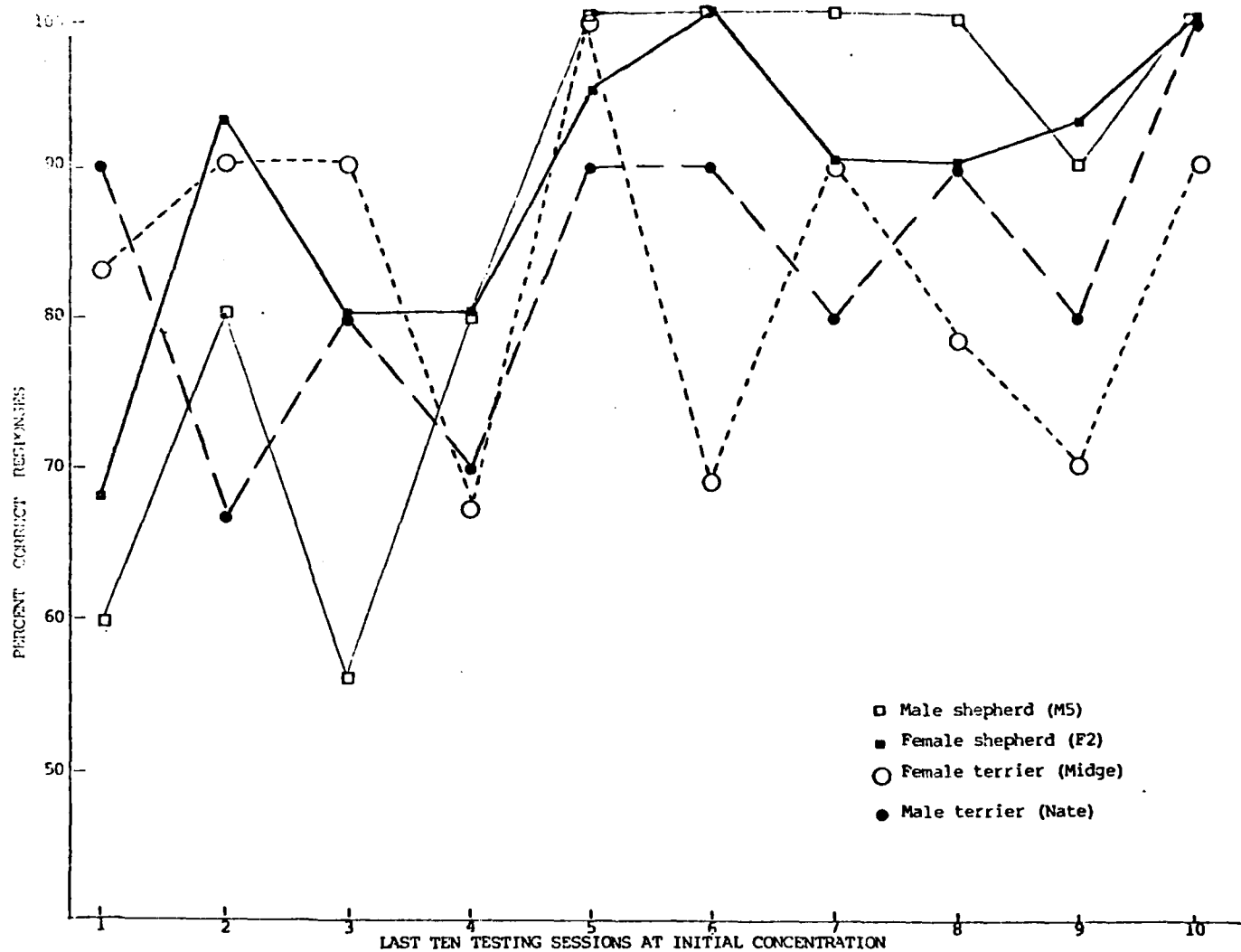


Figure 6. Session-to-session detection performance.

(and highest) test concentration. Additional data for the same four dogs appear in Table 1 which summarizes results from a total of 240 sessions averaging 12 trials/session.

Dog	\bar{X}	S.D.	Total Sessions
M5	73.2	12.5	44
F2	70.3	9.5	20
Midge	70.7	17.2	76
Nate	73.1	11.9	100

Table 1. Combined performance data for three test concentrations: 1.0%, 0.1%, and 0.01% pentyl acetate.

In Fig. 6, noting sessions 4 - 10 in particular, it can be seen that session-to-session variability remained large for the terriers, especially for Midge. While mean overall performance percentages, as given in Table 1, are nearly the same for the shepherds and the terriers, there are large differences in performance variability, standard deviations for both terriers being greater and based on many more sessions. The standard deviation for M5 does not well represent this dog's later performance; in subsequent testing, variability continued to decrease, the S.D. being about 10.4 by the sixtieth session. Figures for the terriers, on the other hand, reflect persisting inconsistencies; in many instances Midge would perform no more than 2 - 3 trials, whereas Nate, although generally eager to work, continued to perform erratically with very low scores interspersed among high ones.

Discussion

The shepherds in this study -- two of which we had worked with earlier -- were as common observations would suggest, generally less excitable than the terriers throughout all phases of training and testing. Reactions to and compatibility with several different handlers were, for the most part, uniform, and presented no special problems. One of the shepherds, a female, showed good initial progress in learning the task but subsequently developed an unexplained aversion to the testing environment. This did not appear to include the handler, nor to have resulted from a misapplication of training techniques; progress in attempting to re-establish workable performance by the same handler -- as well as by a different one -- was slow and only partially successful. The handling techniques and training and testing procedures that we developed in earlier work with shepherds gave generally satisfactory and reliable performance results for all but this animal, which we dropped from the study. By the time that we begun to work with terriers, several important procedural points had been established concerning the control of performance motivation through carefully regulating water intake and the maintenance of effective handling and training procedures. A major portion of the daily total water intake, we found, for example, should be given as rewards during training and testing, and when dogs were being tested on a hand lead, we found it essential, first, to identify and eliminate any cues from the handler and to

strictly control the use of voice commands and praise.

When dogs of either breed are placed in an enclosed, automated testing apparatus, the problems associated with direct handling are replaced with generally less troublesome ones. Solutions to these, we have found, are basically similar, to those that have been worked out in laboratory testing of other species. From a practical standpoint, however, our observations most directly relevant to the field use of dogs for odor detection, we believe, are those based on direct contact between dogs and the handlers working with them. We describe and comment on a number of such observations in the sections that follow below.

Observations on Terriers: Characteristics Influencing Performance

In contrast to shepherds, the young terriers impressed us from the time of their arrival with marked differences in disposition and generally higher levels of activity. They were, and remain, more labile in their responsiveness to people and sensitivity to human affect. The result of this -- and perhaps it is due to keeping this breed in the relative isolation of kennel runs -- has been that it was especially difficult to keep the attention of these dogs directed to the odor detection task. This problem persisted even in those individuals that eventually showed some consistency in performance. Of the four terriers, we judged only one, the largest male, Nate, to have achieved sufficiently stable performance for the data to be considered a reliable measurement of detection abilities, although data from Midge, when she would perform, are useful for compari-

son. In all cases, however, inconsistencies in intra-session and session-to-session performances make quantification and judgements of odor detection abilities difficult. The problem arises from the small numbers of successively obtained performance scores, and the question of how to treat the occurrence of scores, within a long series of observations, that fall well below demonstrated abilities to correctly detect a particular odor concentration. This problem is well recognized in the field of behavioral testing, and certainly may best justify considering odor detection abilities separately from the performance measurements designed to quantify them. These are: "stimulus control" -- denoting a demonstrated focus of sensory capacities and attentional factors -- and "reinforcement control," which generally refers to the effectiveness with which a known and specifically manipulated reinforcer maintains a given performance sequence. In terms of these concepts, our major problem with terriers on the handler-controlled task appears to have been insufficient reinforcement control. Those instances in which Nate and Midge showed high-level detection performance -- interspersed among sessions of poor performance -- indicate that the odor stimulus was in fact being attended to and discriminated from the blank stimulus, at least within individual sessions. The preliminary success we have had in training terriers using the automated testing apparatus appears to support this interpretation.

With respect to potential field use of terriers (or a similar small breed) for odor detection, some of our observations may

be relevant to pre-selection, and to the initial handling and training of individuals. We will comment briefly on each of the terriers, pointing out characteristics both of the dog and of the handlers' techniques that appear to be significant.

Individual dogs. The smallest male, "Ki", was the least responsive of the four to human contacts and voice commands. Reductions in water intake sufficient to motivate his littermates were not effective in getting this animal to drink consistently from the cups in the testing console. Increased water reduction produced drinking, but decreased food intake. Water delivery to the reward cups then appeared to command his full attention, and attempts to direct it to the presence of odor in a sampling port associated with water delivery remained largely unsuccessful. In contrast to the others, Ki appeared to be relatively insensitive either to praise or to mild rebuke, and was noticeably belligerent in the presence of his littermates. After several months of attempting to train this animal he was dropped from the study.

The small female, "Midge," appeared to require less daily water intake than did Ki, and often remained indifferent to water delivered as a reward. In contrast, however, she was highly sensitive and responsive to voice commands, and praise appeared to be especially effective as a reward. She was the first of the remaining three to master the task of finding which of the two sampling ports contained odor. Her responses were rapid, and quickly became well-defined in the sequence of sniffing from the ports and lowering her snout to touch the reward cup beneath

the one containing odor. The main problem with Midge was getting her to consistently perform 10 trials -- set as a minimum per session. Often, she could not be coaxed to perform at all, but when she would, praise appeared to be the more effective reinforcer. At times, she rapidly consumed water delivered on the first several trials (usually performed correctly) then quickly lost interest in the task. Reinforcement control with this animal was never satisfactorily achieved in the handler-controlled task.

The second male, "Jack", had originally been housed with Ki and appeared to have been intimidated by his smaller litter-mate: Ki clearly was the dominant of the two. Jack was underweight and had become increasingly timid in the presence of Ki; he was moved to a run by himself and gained weight, but his timidity persisted and appeared to have generalized to humans. He remained extremely sensitive to any words from a handler, and sometimes responded as if punished by retreating to a corner or assuming a defferent posture. After the earliest sessions introducing this dog to the testing environment, all rebuke was strictly avoided, and voice commands were reduced to a minimum. As the term has been applied to rats, Jack displayed a high degree of "emotionality". The effect of this on performance was to limit the number of trials that could be run, as he often seemed preoccupied with watching the handler and had to be patiently coaxed to perform. When this dog did run a series of trials, his abilities to find the odor stimulus and signal a choice were satisfactory.

The largest male, "Nate," appeared from our earliest observations to show moderate and appropriate reactions to his littermates and to humans. He was robust, "unemotional", and docile in the sense of being well suited for training. In disposition, this animal most closely resembled the better performers among the shepherds. While Nate was slower to learn the detection task than was the small female, Midge, the consistency with which he performed was markedly better throughout all phases of the study. He learned to obey voice commands with little difficulty and seldom failed to perform ten or more trials per session.

Concluding Comments

Our original aim in studying terriers -- and it remains primary in continuing studies -- was to obtain quantitative odor detection data for comparing the abilities of a small breed with those of shepherds. For the reasons we have pointed out, this was not possible with the present handler-controlled task; further training of terriers using the automated testing apparatus has eliminated certain problems and has proven more successful.

We have noted, however, that the conditions of the present study are similar to those applying in field training situations. For this reason, our results and observations (along with the impressions summarized below) may be of interest to those concerned with the selection and training of small dogs for tasks similar to the one we have described. We hasten to point out,

however, that with a single litter of terriers as a sample, conclusions applying to the breed or to small dogs in general are clearly not warranted. What we offer are impressions based as closely as possible on points of agreement among the several handlers who worked with the dogs.

The results of training showed that the small female, Midge, learned the task more rapidly than the largest male, Nate, and probably was more highly sensitive to odor. In our experience with shepherds, this also has appeared to be true of females. However, an apparently more important point concerning terriers -- one that has been less so in our experience with shepherds -- is that the male, Nate, was clearly better suited to the task on the basis alone of his predictable willingness to perform on command and to work consistently. The same would appear to apply to the male, Jack, at least in a limited number of sessions.

The two best performers, a small female (Midge) and the largest male (Nate), displayed the least "emotionality" when interacting both with littermates and humans. Neither one showed excessive attention to the handlers when exercised on walks outside the kennel: they tended to ignore the handlers and devote full attention to any new objects and smells that they encountered. These together seem to us to be particularly important characteristics correlated with success in establishing both stimulus control (continued focussing of attention on the specified odor stimulus) and reinforcement control -- the continuing effectiveness of a specified reinforcer in maintain-

ing the desired response sequence, i.e., searching for and locating the odor stimulus.

PUBLICATION AND PRESENTATIONS BASED ON WORK SUPPORTED BY AFOSR

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